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THE PROBABILISTIC DESIGN APPROACH TO HEICAL COIL SPRING USING ANSYS PDS

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Abstract— Traditionally springs are made of metal materials. The basic design parameters such as geometric, material and loads are all random variables and the randomness in these variables should be taken into account while designing helical coil spring. Hence, this work presents a probabilistic approach for the design of helical springs. Probabilistic design approach is used within framework of ANSYS. Further this work presents development of mathematical models to predict the strength of a typical helical spring as a function of geometrical parameters. This work presents unique method (probabilistic design) to investigate engineering problem, its analysis, mathematical modeling with the help of ANSYS and MATLAB. From study it appears that the wire radius and force have significant influence on the output parameter for inside and outside stress. FEA tools such as ANSYS is used along with analytical and experimental validation to ensure safe design of springs. Recently, it is observed that PDS (Probabilistic Design System) within ANSYS can be used to take care of such uncertainties in design parameters. On the other hand, modulus of elasticity and force has a significant influence on for maximum deflection.

KEYWORDS: HELICAL SPRING, PROBABILISTIC DESIGN, REGRESSION ANALYSIS, ANSY

INTRODUCTION

Traditionally springs are made of metal materials. Springs tend to be highly stressed because they are designed to fit into small spaces with the least possible weight and lowest material cost. At the same time they are required to deliver the required force over a long period of time. The reliability of a spring is therefore related to its material strength, design characteristics, and the operating environment [4]. Among the different types of mechanical springs helical springs are commonly integrated as a part of much mechanical system such as a shock absorber. According to different loadings applied helical springs can be divided in compression, tension and torsion spring. The factor to be considered in a design of a spring is the strain energy of the material [8]. The material with lower Young's modulus (E) or density (ρ) will have relatively higher specific strain energy under same stress Present work will be carried out on design of experiment to know the effect of imperfections on inside diameter of spring on the compressive strength of helical coil spring. Major factors that affect the strength of springs are Design parameters, material selection, Raw material defect, spring geometry and surface imperfection [1]. The design parameters i.e. Operating modes, Operating temperature, shot peening and imperfections on inside the coil spring affect directly on fatigue life of spring, as we seen as temperature increases the modulus and torsional yield strength of spring material decreases [11]. If the inner side of the coil spring is shot preened the stresses on inside coil surface reduces and fatigue life of coil spring increases. The presence of any impurity, inclusion in raw material reduces the strength of coil spring. In the F.E.A. model of corrosion the linear triangular element is used and for part model of imperfection the linear quadrilateral element is used [3]. FEA tools such as ANSYS is used along with analytical and experimental validation to ensure safe design of springs. Recently, it is observed that

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PDS (Probabilistic Design System) within ANSYS can be used to take care of such uncertainties in design parameters [14]. Hence, present work proposes strength prediction of helical coil spring using PDS within ANSYS.

METHODOLOGY:

Designing the spring by coils/turn, free length and spring diameter. Probabilistic designing is performed by using FEM package (ANSYS). It will help to know the influence of different design and spring geometry parameters on compressive strength of helical spring [9]. Recently, analyses have been carried out through the implementation of numerical routines. The FEM is a numerical procedure for obtaining approximate solutions to many problems encountered in engineering analysis [7]. Through the use of finite element analysis (FEA), comparisons can be made between the numerical results and to those of existing analytical models. A good finite element model must accurately represent the geometrical and physical properties of the actual body [2]. The stress distribution in a helical compression spring is considered to be constant along the length of the wire, excluding the spring end. Numerical modeling consisted of a circular wire compression spring using ANSYS. A finite element model of a helical compression spring was built to facilitate analysis and optimization by the ANSYS finite element program. A finite analysis of element was performed to examine the local stress distribution around a specified defect by means of a typical coil spring [12]. Initially the complete stress distribution was examined devoid of any defect in the material, and subsequently at the location where the maximum stress was discovered, every defect was added. In the view of the fact that the size of the defect is considerably smaller to the whole model, a technique of sub-modelling was used [5] [13]. This method is used to examine a local part of a system by means of refined meshing based on the result of FEA of a universal model by means of coarse meshing. Present work uses ANSYS for FE analysis of helical spring and its components. ANSYS is widely used FE analysis software both in academics as well as in industry. Using ANSYS one can perform various tasks of FE analysis to meet the user requirements of various type of analysis [10]. There are two different user interfaces available i.e. ANSYS classic and ANSYS workbench. Traditionally, ANSYS classic is choice of analysts but of late ANSYS workbench is becoming popular with analysts. There are two distinct modes of ANSYS usage, i.e., the Graphical User Interface (GUI) and Batch Mode. Batch mode of ANSYS, which is themethod preferred by advanced ANSYS users and also required by various advanced technologies [6]. Probabilistic design is perforemed using ANSYS to know sensitivity of each parameter on stress and deflection.

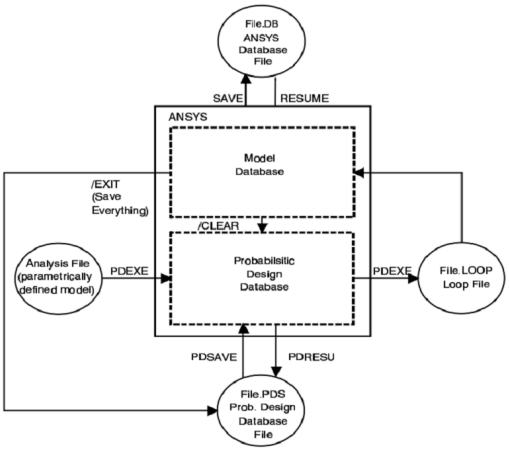

Fig1: an overview of information flow during analysis of probabilistic design.

RESULTS:

Various results such as shear strength and deflections are typically studied for helical spring. Present work investigates effect of various input uncertainties on stress and deflection. One of the objectives of this research is to study probabilistic response analysis of helical spring. The result of the proposed method is Spearman rank-order correlation to determine which random parameters are most significant in affecting the uncertainty of the design. The sensitivities are given as relative values (bar chart) and relative to each other (pie chart). From Figure as shown below, the wire radius and force have significant influence on the output parameter for inside and outside diameter. On the other hand, modulus of elasticity and force

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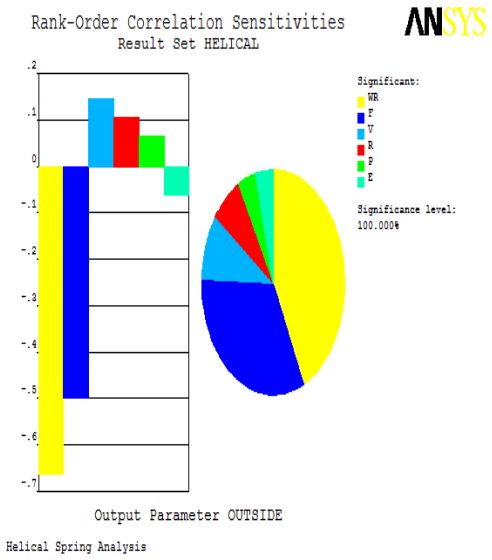
has a significant influence on for maximum deflection.



CONCLUSION

The probabilistic design of helical coil spring used in shock absorber of bike using ANSYS PDS feature was carried out. Probabilistic design uses Gaussian distribution for various input parameters and simulation uses Monte Carlo simulation technique for sampling. The wire radius and force have significant influence on the output parameter for inside and outside stress. On the other hand, modulus of elasticity and force has a significant influence on for maximum deflection. Analytically calculated stress and deflection in helical spring is lower than allowable limit of material. This ensures safe design of helical spring based on analytical formulations. Although current study presents successful probabilistic design of helical spring using FEA formulation, there are various areas which can be considered as future scope of the work. Some of the important scope for future work is as mentioned below: Coupled structural-thermal analysis can be carried out using similar approach to check effect of thermal parameters on helical spring of shock absorber. Design optimization can be carried out using FEA based tool such as ANSYS.

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